FACT SHEET

NUCLEAR ENERGY INSTITUTE

SUITE 400
1776 I STREET, NW
WASHINGTON, DC
20006–3708
202.739.8000
www.nei.org

Beneficial Uses of Radiation

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Key Facts

■ Radiation, a form of energy abundant in nature, has been harnessed by man to provide hundreds of beneficial uses. Controlled use of radioisotopes, which are found in nature as well as made by man, are used in X-rays, medical diagnosis and treatment, common household products such as television sets and smoke alarms, and electricity from nuclear power plants, basic scientific research, manufacturing, minerals exploration and agriculture.

■ America's digital economy and high standard of living would not be possible without the use of radioactive materials. These materials make many processes better, easier, quicker and cheaper. In some cases, there are no alternatives to radioactive materials.

■ The use and handling of man-made radiation is strictly controlled and regulated by the U.S. Nuclear Regulatory Commission.

■ Radioactive materials also provide substantial economic and employment benefits to Americans. Every year, radioactive materials are responsible for approximately $420.7 billion in total industry sales, 4.4 million jobs and $77.8 billion in tax revenues to local, state and federal governments.

How Radiation Is Used: Benefits of Man-Made Radiation

Just as early man harnessed fire to improve his life, mankind in the 20th century was able to harness radiation. The development of nuclear technology is one of the most significant achievements of the 20th century, according to the National Academy of Engineering. Today nuclear technology is used in nearly every field and aspect of our lives—from medicine, to manufacturing and construction, to powering common household items, to producing electricity for one of every five U.S. homes and businesses.

Here are some of the many ways radiation benefits us all:

Medicine. Every year, one in three of the 30 million Americans who are hospitalized is diagnosed or treated with nuclear medicine techniques. Radionuclides are used in more than 11 million nuclear medicine procedures every year in the United States, prolonging and improving the quality of thousands of lives. They are also used in 100 million laboratory tests on body fluid and tissue specimens. Today, approximately 500,000 cancer patients in the United States receive radiation treatment at some point in their therapy. Radioisotopes and X-rays also are used to diagnose and treat scores of other diseases.

Diagnosis is one of the main uses of nuclear medicine, which is one of the most powerful diagnostic tools known today. It is made possible by the ability of some natural elements to concentrate in certain parts of the body. For example, iodine concentrates in the thyroid, phosphorus in the bones, and potassium in the muscles.

In nuclear medicine, these elements are introduced into a patient's body in radioactive form—as "radioisotopes." A special camera then takes pictures of the internal workings of the organ, providing striking detail. For example:

- Myocardial perfusion imaging maps the blood flow to the heart, allowing physicians to see whether a patient has heart disease and determine the most effective course of treatment.

- Bone scans can detect the spread of cancer six to 18 months sooner than X-rays.

- Kidney scans are much more sensitive than X-rays or ultrasound in fully evaluating kidney function.
- Imaging with radioactive technetium-99m can help diagnose bone infections at the earliest possible stage.
- Laboratory techniques using radioactivity can detect underactive thyroids in newborn babies, making prompt treatment possible and saving many children from mental retardation.

Radionuclides—in a stronger form—also can be used to treat disease. When former President George H.W. Bush and Mrs. Bush suffered from Graves' disease, a thyroid condition, they were cured by drinking a form of radioactive iodine that concentrates naturally in the thyroid and destroys the diseased portion. This treatment is so successful that it has virtually replaced thyroid surgery.

Radioactive iodine is also widely used to treat thyroid cancer. Compared to drug therapy, it has a lower recurrence rate and avoids potentially fatal side effects like the destruction of bone marrow.

Radiation is also used to sterilize hospital items, thereby helping prevent the spread of diseases without making the items radioactive. Because of its penetrating power, radiation is particularly suitable for sterilizing items such as sutures, syringes, catheters and hospital clothing, which are packed in hermetically sealed packages prior to sterilization. Heat cannot be used to sterilize these items because it would destroy the materials.

Energy. Nuclear power plants generate 20 percent of the United States' electricity and 17 percent of world's electricity. In producing one-fifth of America's electricity, U.S. nuclear plants cut emissions of carbon dioxide, the principal greenhouse gas, by 189.5 million metric tons of carbon in 2002.

Scientific Research. Radioactive materials are integral to research in nearly all fields of modern science. The Food and Drug Administration requires all new drugs to be tested for safety and effectiveness. More than 80 percent of those drugs are tested with radioactive materials.

Radioactive materials also are essential to the biomedical research that seeks causes and cures for diseases like AIDS, cancer and Alzheimer's disease.

Radionuclides are used extensively in metabolic studies, genetic engineering and environmental protection studies.

Carbon-14, a naturally occurring, long-lived radioactive substance, allows archaeologists to determine when artifacts containing plant or animal material were alive, created or used. For example, carbon-14 dating showed that the Shroud of Turin did not belong to the period when Christ was alive.

Museums rely on radioactive materials to verify the authenticity of paintings and art objects.

Criminology also makes use of radiation, where neutron activation analysis is used for chemical analyses. Criminal investigators use radiation to examine physical evidence and to link suspects to crimes. An example is the detection of the toxic element arsenic in hair, which can be detected through the irradiation of just a single strand.

Agriculture and Food Products. More than 40 countries have approved the use of radiation to help preserve nearly 40 different varieties of food. Not all have yet approved the sale of irradiated food on the open market.

The process exposes food to high doses of radiation from cobalt-60. This process kills bacteria, insects and parasites, while the food itself remains safe without becoming radioactive. In the United States, the federal government has approved the use of irradiation for fruits, vegetables, pork, poultry, red meat and spices. The first major U.S. plant to use the process opened near Tampa, Fla., in 1992 to process fruits, vegetables and poultry.

Other food processors have been slow to adopt the technique because of concerns about consumer acceptance, even though irradiated foods are regularly eaten by astronauts on space missions. In May 2003, the U.S. Department of

Agriculture cleared the way for irradiated ground beef to be available to schools through the National School Lunch program.

In agriculture, radiation has been used to breed new seed varieties with higher yields, such as the "miracle" rice that has greatly expanded rice production in Asia. By the end of the 1980s, radiation had been used successfully to eradicate approximately 10 species of pest insects in wide areas, preventing agricultural catastrophes. These include the Mediterranean fruit fly in Japan and Mexico, the tsetse fly in Africa and the screwworm fly in North Africa, the United States and Mexico. The process is known as the sterile insect technique. Millions of male insects are sterilized with gamma radiation so they are unable to mate productively. Then they are released into fields to mate with female insects. Such mating produces no offspring, so the cycle of infestation is broken.

Radiation has also been used to:

- develop hundreds of varieties of hardier, more disease-resistant crops—including peanuts, tomatoes, onions, rice, soybeans and barley—in agricultural research laboratories
- improve the nutritional value of some crops, as well as improve their baking or melting qualities or reduce their cooking time
- pinpoint where illnesses strike animals, allowing the breeding of disease-resistant livestock
- show how plants absorb fertilizer, helping researchers learn when fertilizer should be applied and how much is needed, which helps prevent overuse, a major source of soil and water pollution.

Space Exploration (Powering Us Into Space). Radioisotope thermoelectric generators (RTGs) are used to provide power for unmanned spacecraft. RTGs use the natural decay of plutonium dioxide to produce heat, which is transferred into electrical power through thermoelectric devices. A typical modern RTG produces about 300 watts and will operate unattended for many years. RTGs have been used to provide power for 24 U.S. space missions—with an unparalleled safety record. These include the Apollo Lunar Surface Experimental Packages, the Pioneer 10 and 11 spacecraft launched in 1972 and 1973 (whose RTGs are still operating), two Viking Mars spacecraft (1978), two Voyager spacecraft (1977), and the Galileo (1989), Ulysses (1990) and Cassini (1997) spacecraft.

Powering the U.S. Navy Fleet. Nuclear reactors are used to power both surface ships and submarines. The U.S. Navy has built more than 200 nuclear-powered ships and steamed more than 100 million miles on nuclear energy. The Navy operates 98 nuclear-powered submarines and 11 nuclear-powered surface ships. Nuclear propulsion gives submarines two major advantages—speed and underwater range without surfacing. The modern U.S. submarine, for example, can cruise up to one million miles, or more than 25 years, without refueling. Modern nuclear-powered surface ships, including aircraft carriers, can operate continuously at high speeds for extended periods without the need for support ships.

Industry, Manufacturing, Engineering. Today, practically every industry uses radioactive materials. Radioisotopes are used to improve the quality of manufactured goods in thousands of industrial plants throughout the world. Because radiation loses energy as it passes through substances, industry has been able to develop highly sensitive gauges to measure the thickness and density of many materials, as well as imaging devices to inspect finished goods for weaknesses and flaws.

Small amounts of a radioactive substance are commonly used as tracers in process materials. They make it possible to track leakage from piping systems, monitor the rate of engine wear and corrosion of processing equipment, observe the velocity of materials through pipes and gauge the efficiency of filtration systems.

Radiation is also used to "cold sterilize" plastics, pharmaceuticals, cosmetics and other products that are too heat-sensitive to be sterilized in other ways.

Radiation detection instruments are widely used because they make it possible to take measurements without direct physical contact with the substance being measured. For example, level gauges containing radioactive sources are used where heat, pressure or corrosive substances, like molten glass or metal, make it difficult or impossible to use direct contact gauges.

Radioactive materials are also used by:

- the automobile industry to test the quality of steel in cars
- aircraft manufacturers to check for flaws in jet engines
- mining and petroleum companies to locate and quantify oil, natural gas and mineral deposits
- manufacturers to obtain the proper thickness of tin and aluminum
- pipeline companies to look for defects in welds
- oil, gas and mining companies to map geological contours, using test wells and mine bores, and to determine the presence of hydrocarbons
- construction crews to gauge the density of road surfaces and subsurfaces.

Consumer Products and Services. Radioactive materials supply necessities and conveniences that virtually everyone depends on. Including:

- Many smoke detectors—installed in nearly 90 percent of U.S. homes—rely on a tiny radioactive source to sound an alarm when smoke is present.
- Computer disks “remember” data better when they are treated with radioactive materials.
- Nonstick pans are treated with radiation to ensure that the coating will stick to the surface.
- Photocopiers use small amounts of radiation to eliminate static and prevent paper from sticking together and jamming the machine.
- Cosmetics, hair products and contact lens solutions are sterilized with radiation to remove irritants and allergens.
- Radioactive materials also are used to sterilize medical bandages and a variety of personal health and hygiene products.

Economic and Employment Benefits. Each year in the United States, radioactive materials are directly and indirectly responsible for about $420 billion in total industry sales, 4.4 million jobs and $77.8 billion in federal, state and local government tax revenues.

The states reaping the greatest economic benefits from radioactive materials are California, Minnesota, Oregon, Pennsylvania, Tennessee, Virginia and Washington.

(See the list of common radioisotopes beginning on the next page.)

This fact sheet is available at www.nei.org, *where it is updated periodically.*

Common Radioisotopes and Their Uses

Americium-241	Used in many smoke detectors for homes and businesses to measure levels of toxic lead in dried paint samples, to ensure uniform thickness in rolling processes like steel and paper production, and to help determine where oil wells should be drilled.
Cadmium-109	Used to analyze metal alloys for checking stock and sorting scrap.
Calcium-47	Aid to biomedical researchers studying the cell function and bone formation of mammals.
Californium-252	Used to measure the mineral content of coal ash and to measure the moisture of materials stored in silos.
Carbon-14	Used in research to ensure that potential new drugs are metabolized without forming harmful by-products.
Cesium-137	Used to treat cancers; to calibrate the equipment used to measure correct patient dosages of radioactive pharmaceuticals; to measure and control the liquid flow in oil pipelines; to tell researchers whether oil wells are plugged by sand; and to ensure the right fill level for packages of food, drugs and other products. (The products in these packages do not become radioactive.)
Chromium-51	Used in research in red blood cell survival studies.
Cobalt-57	Used in nuclear medicine to help physicians interpret diagnostic scans of patients' organs, and to diagnose pernicious anemia.
Cobalt-60	Used to sterilize surgical instruments; to improve the safety and reliability of industrial fuel oil burners; and to preserve poultry, fruits and spices.
Copper-67	When injected with monoclonal antibodies into a cancer patient, helps the antibodies bind to and destroy the tumor.
Curium-244	Used in mining to analyze material excavated from pits and slurries from drilling operations.
Iodine-123	Widely used to diagnose thyroid disorders.
Iodine-129	Used to check some radioactivity counters in *in vitro* diagnostic testing laboratories.
Iodine-131	Used to diagnose and treat thyroid disorders. (Former President George H.W. Bush and Mrs. Bush were both successfully treated for Graves' disease, a thyroid disease, with radioactive iodine.)
Iridium-192	Used to test the integrity of pipeline welds, boilers and aircraft parts.

Beneficial Uses of Radiation

Krypton-85	Used in indicator lights in appliances like clothes washers and dryers, stereos and coffeemakers; to gauge the thickness of thin plastics, sheet metal, rubber, textiles and paper; and to measure dust and pollutant levels.
Nickel-63	Used to detect explosives and as voltage regulators and current surge protectors in electronic devices.
Phosphorus-32	Used in molecular biology and genetics research.
Plutonium-238	Has safely powered at least 20 NASA spacecraft since 1972.
Promethium-147	Used in electric blanket thermostats and to gauge the thickness of thin plastics, thin sheet metal, rubber, textiles and paper.
Selenium-75	Used in protein studies in life science research.
Sodium-24	Used to locate leaks in industrial pipelines and in oil well studies.
Strontium-85	Used to study bone formation and metabolism.
Strontium-90	Used in survey meters by schools, the military and emergency management authorities.
Technetium-99m	The most widely used radioactive isotope for diagnostic studies in nuclear medicine. Different chemical forms are used for brain, bone, liver, spleen and kidney imaging and also for blood flow studies.
Thallium-204	Measures the dust and pollutant levels on filter paper and gauges the thickness of plastics, sheet metal, rubber, textiles and paper.
Thoriated tungsten	Used in electric arc welding rods in the construction, aircraft, petrochemical and food processing equipment industries. It produces easier starting, greater arc stability and less metal contamination.
Thorium-229	Prolongs the life of fluorescent lights.
Thorium-230	Provides coloring and fluorescence in colored glazes and glassware.
Tritium	Used for life science and drug metabolism studies to ensure the safety of potential new drugs; for self-luminous aircraft and commercial exit signs; for luminous dials, gauges and wristwatches; and to produce luminous paint.
Uranium-238	Used in dental fixtures like crowns and dentures to provide natural color and brightness and in fuel for nuclear power plants and naval nuclear propulsion.
Xenon-133	Used in nuclear medicine for lung ventilation and blood flow studies.